ICE-SHELF COLLAPSE SCENARIO IN PINE ISLAND BAY, WEST ANTARCTICA: A MODEL STUDY.

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INTRODUCTION

In this study, we investigate a scenario by which the ice shelf of a major ice stream is progressively removed due to climate warming, and the ice stream response to the disparition of the ice shelf, that is disparition of the ice-shelf back stress. The experiment is set up within the galciological context of Pine Island Glacier, in West Antarctica, using a finite element model of coupled ice stream / ice shelf flow.

The model consists of a finite element code (from Mac Ayeal), using a mesh generated by Argus meshmaker, based on the actual glacier geometry. We meshed the area of Pine Island Glacier with tree-node triangular elements.

We drew a contour of the study area, using a tidal interferogram of Pine Island Glacier. With Argus meshmaker, we defined several layers:
- the ice stream part
- the ice shelf part
- 2 margins (drawn along the 2 sides of the ice flow velocity field)
- some ice rises, (on the ice shelf part) where the velocity is null

For our model, we used the following data:

- a surface map of the area
- a bed elevation map
- an accumulation map

- the SAR velocity (usefull but uncomplete data)

We created the thickness, equal to the surface minus the bed for the ice stream part, and equal to the surface*factor for the ice shelf part, factor which is equal to $\frac{\rho_water}{\rho_water-\rho_ice}$.
We specified an area in between, with no data, where we interpolated the data from our 2 domains, to make it smooth and continuous.

The finite element code calculates the ice flow velocity field, and allows us to play with several parameters to make the model velocity fit with the SAR velocity.
We specify the degre of grounding in the ice-stream part through a variable basal friction coefficient, and we add some softening coefficient on the margins of the glacier to increase or decrease the model speed.

First, we caculated the present velocity field, then the new thickness and velocity after several decades, and then we removed the ice-shelf part and see the response of the remaining ice stream.

CONCLUSIONS

The model can fit pretty well the SAR velocity, but the basal friction coefficient needs to be in some way dependant of the known SAR velocity, on the ice-stream part.
The model helped us anyway to complete the velocity on the ice-shelf part, with great accuracy.

If the ice shelf tends to disappear, due to basal melting for instance, the model shows that the velocity is increased by about 30%. The presence of the ice shelf is thus essential for maintening an ice sheet in state of mass balance.

Ice-shelf collapse scenario in Pine Island Bay, West Antarctica:

a model study

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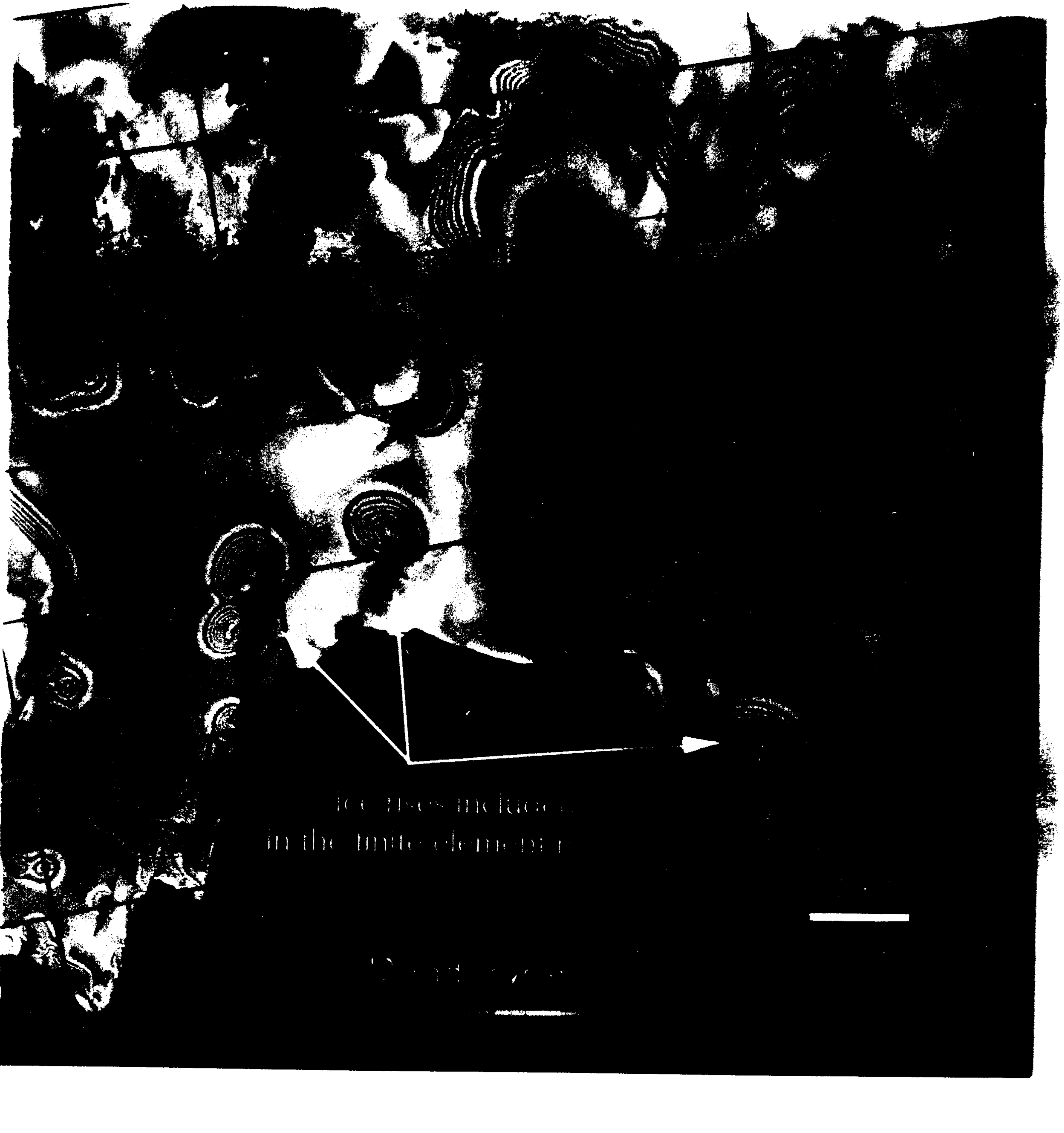
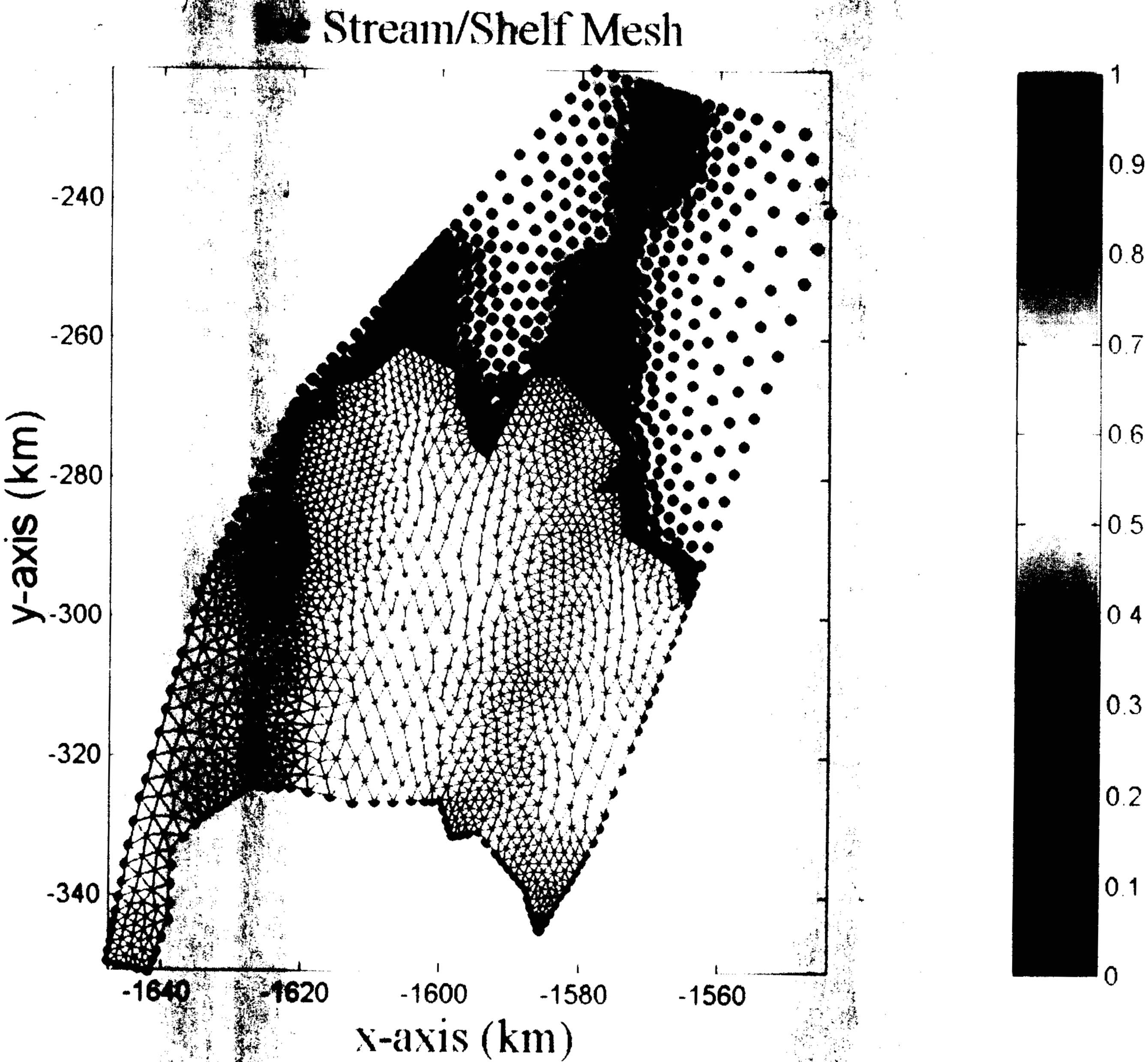
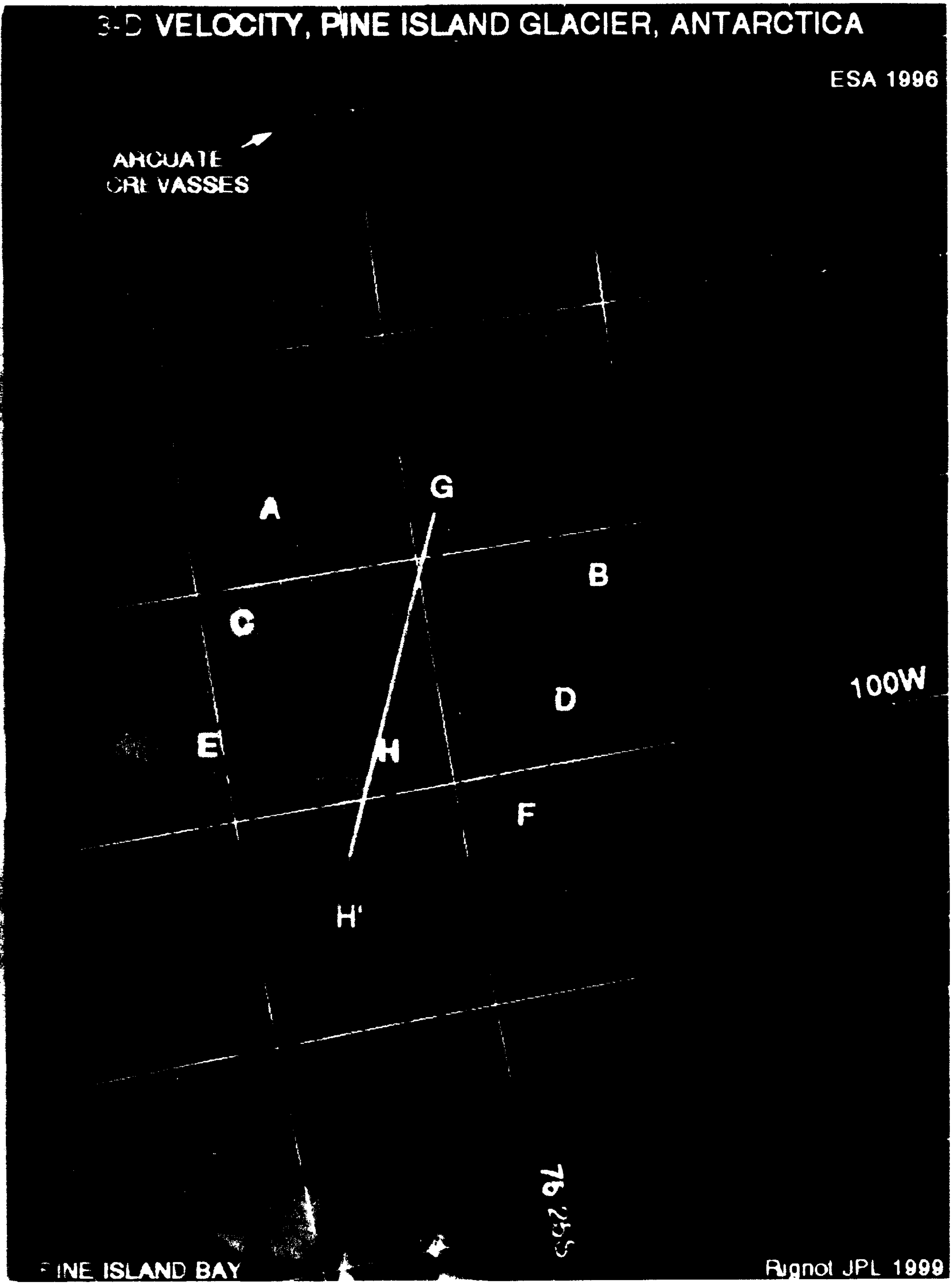
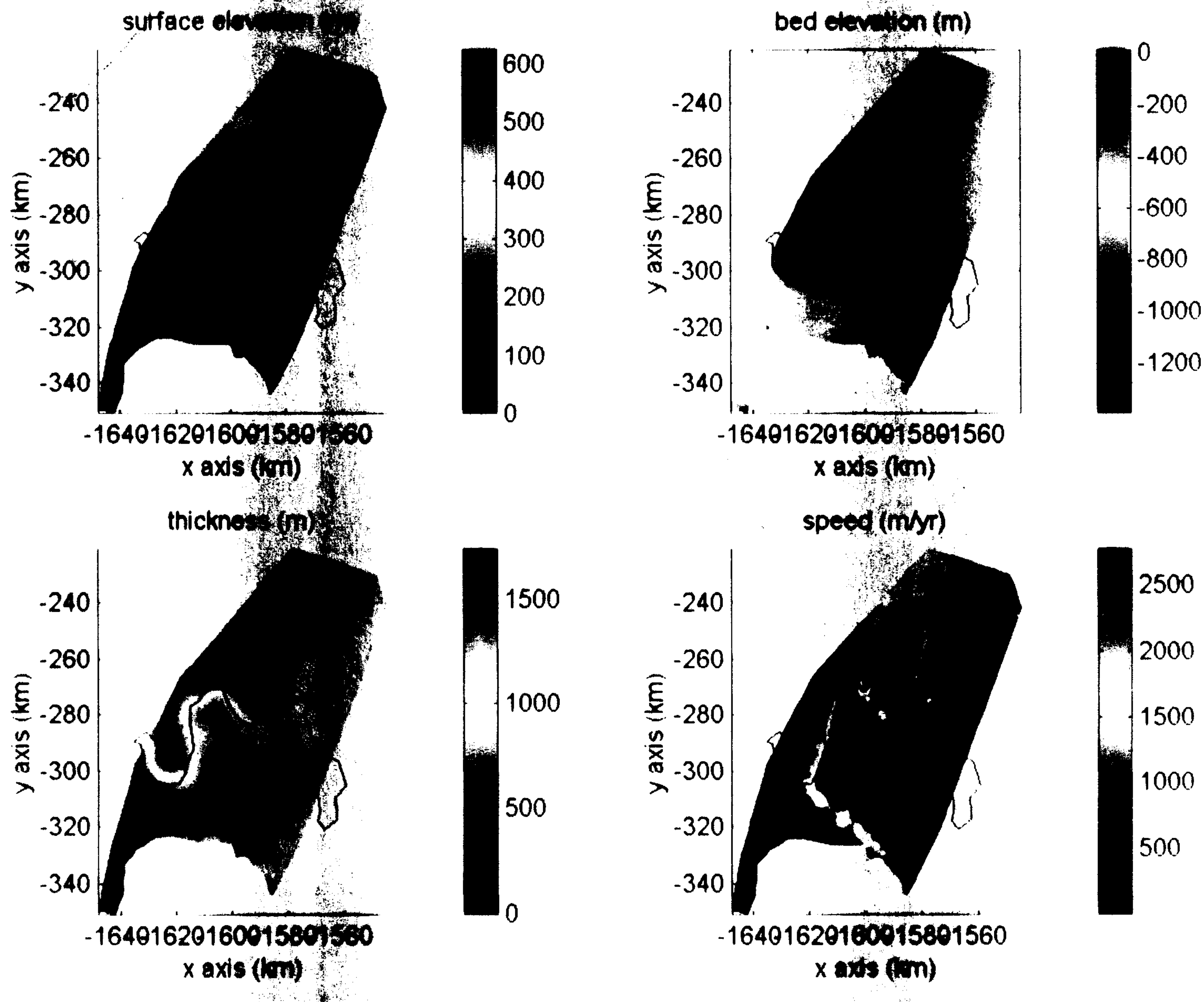
Tidal interferogram of Pine Island Glacier used as a background for our mesh

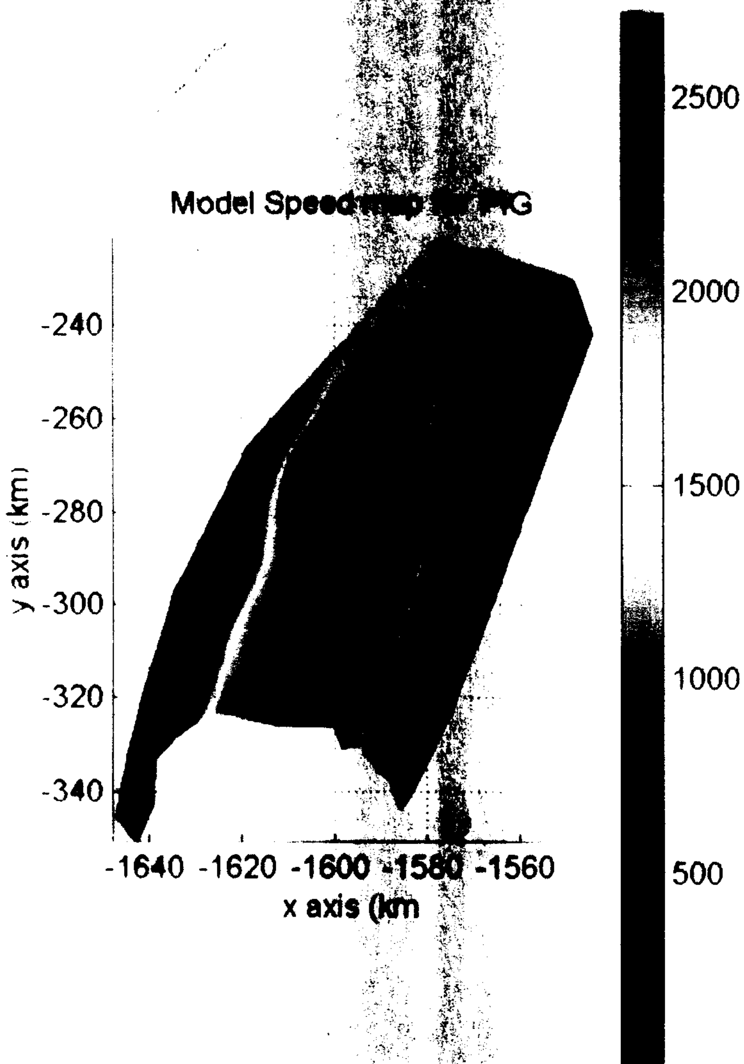

ice rises
in the finite element

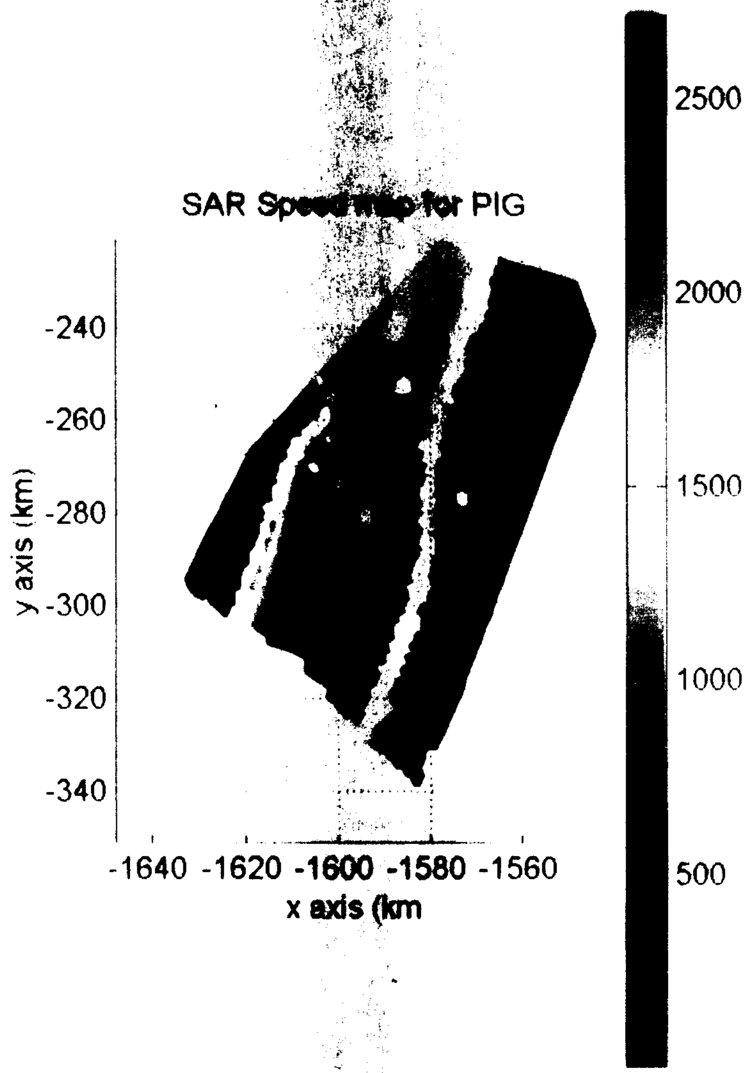

Stream/Shelf Mesh
y-axis (km)
-240
-260
-280
-300
-320
-340
x-axis (km)
-1640
-1620
-1600
-1580
-1560
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


3-D VELOCITY, PINE ISLAND GLACIER, ANTARCTICA
ESA 1996
ARCUATE
CREVASSES
G
A
B
C
100W
D
E
H
F
H'
76 25S
PINE ISLAND BAY
Rignot JPL 1999

Data interpolated to the mesh




Model Speed map for PIG
y axis (km)
-240
-260
-280
-300
-320
-340
-1640 -1620 -1600 -1580 -1560
x axis (km
2500
2000
1500
1000
500


SAR Speed map for PIG
y axis (km)
-240
-260
-280
-300
-320
-340
-1640 -1620 -1600 -1580 -1560
x axis (km
2500
2000
1500
1000
500